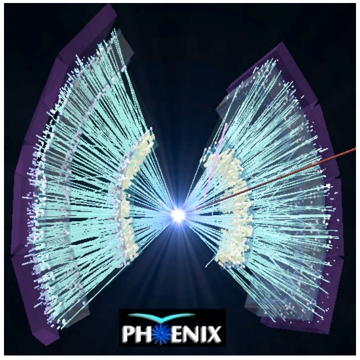
Energy loss of hard scattered partons in Au+Au collisions determined from measurements of π^0 and charged hadrons

M. J. Tannenbaum
Brookhaven National Laboratory
Upton, NY 11973 USA

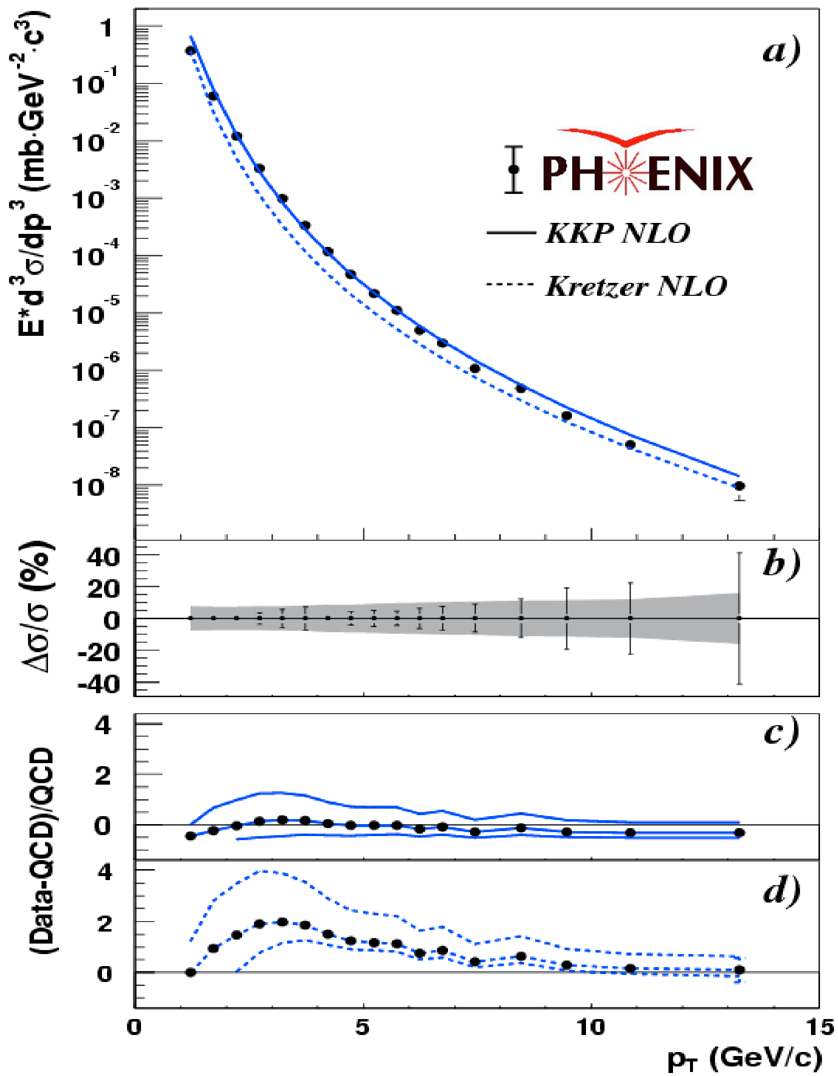
PHENIX Collaboration

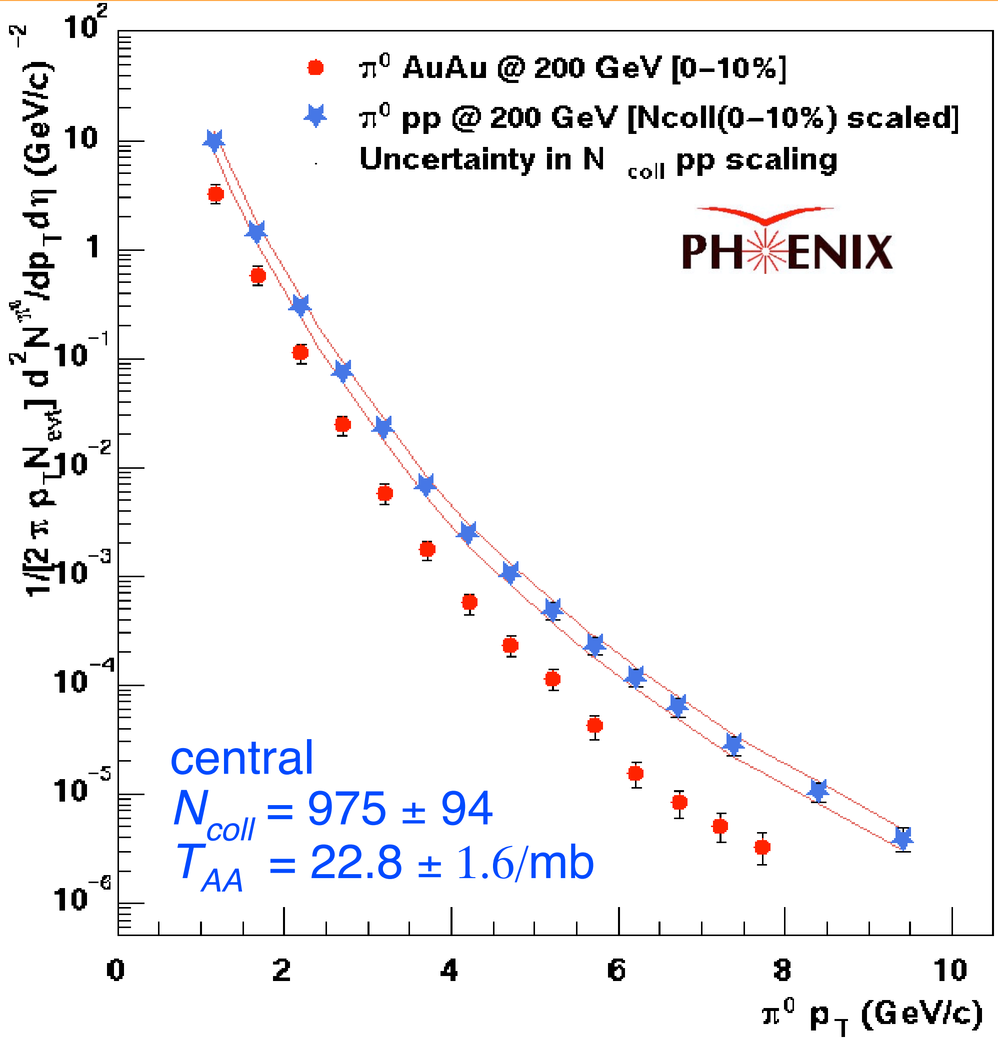


See nucl-ex/0410003

DNP 2004, Chicago IL
October 30, 2004

``THE most exciting discovery at RHIC''-MJT





- π^0 cross section in p-p agrees with QCD

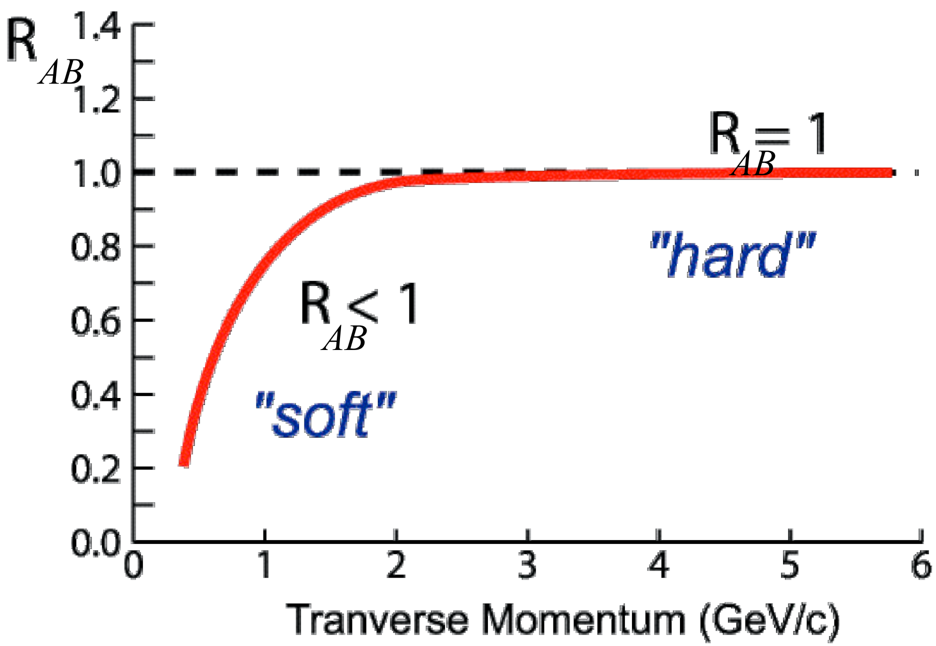
- π^0 cross section in Au+Au is suppressed w.r.t. T_{AA} scaled `calibrated p-p reference'

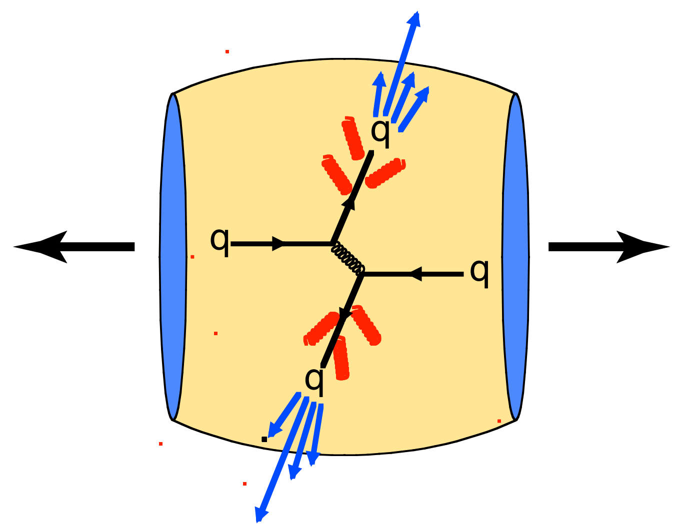
The Nuclear Modification Factor R_{AB} is the ratio of pointlike scaling of an A+B measurement to p-p

Nuclear Modification Factor:

$$R_{AB}(p_T) = \frac{d^2N^{AB}/dp_T d\eta}{T_{AB} d^2\sigma^{pp}/dp_T d\eta} = \frac{M(p_T)}{R(p_T)}$$

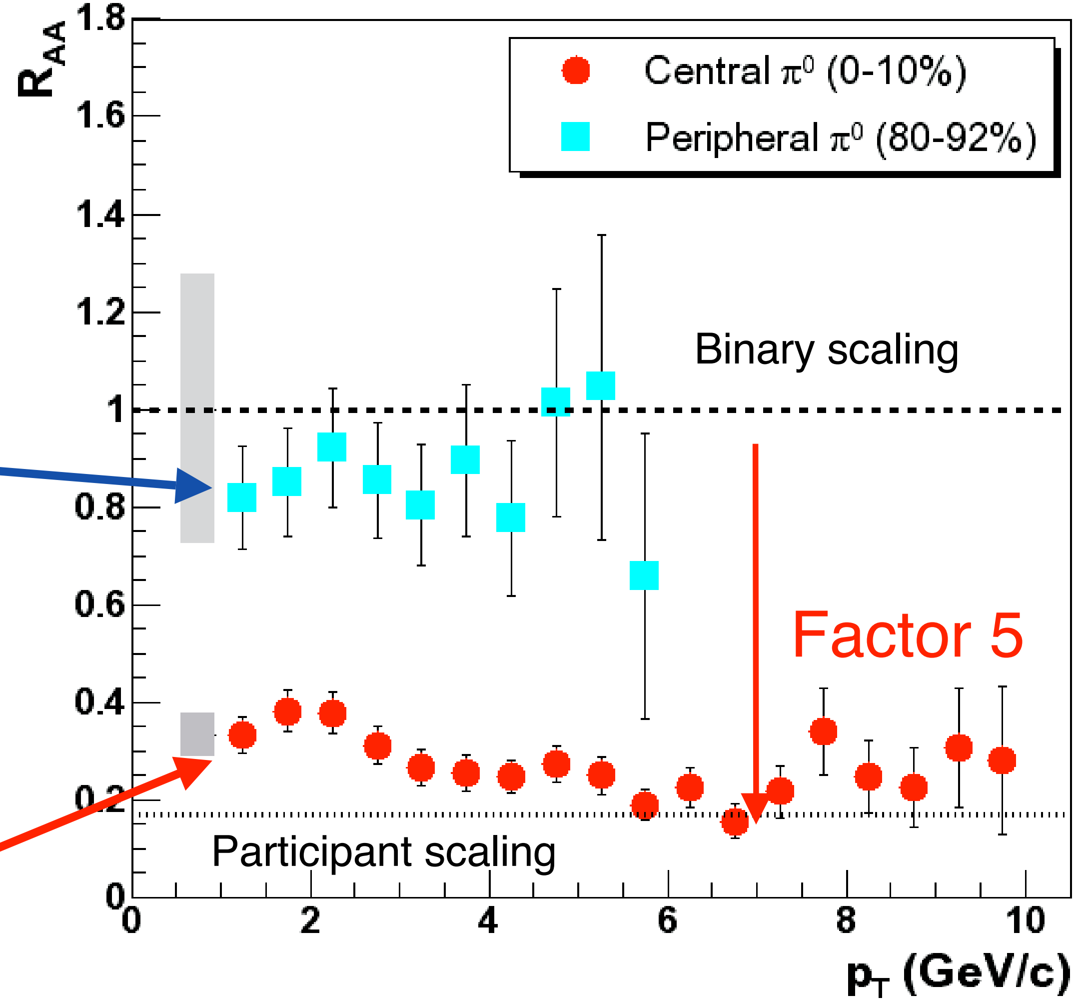
$$T_{AB} = N_{coll}/\sigma^{NN}_{Inel}$$





R_{AA} (π^0) AuAu:pp 200GeV
High p_T Suppression flat from 3 to 10 GeV/c !

Peripheral AuAu - consistent with N_{coll} scaling (large systematic error)



Large suppression in central AuAu ~ constant p_T >4 GeV/c

PRL 91, 072301 (2003)

Control Experiment d+Au shows Cronin effect

Theory explains both:

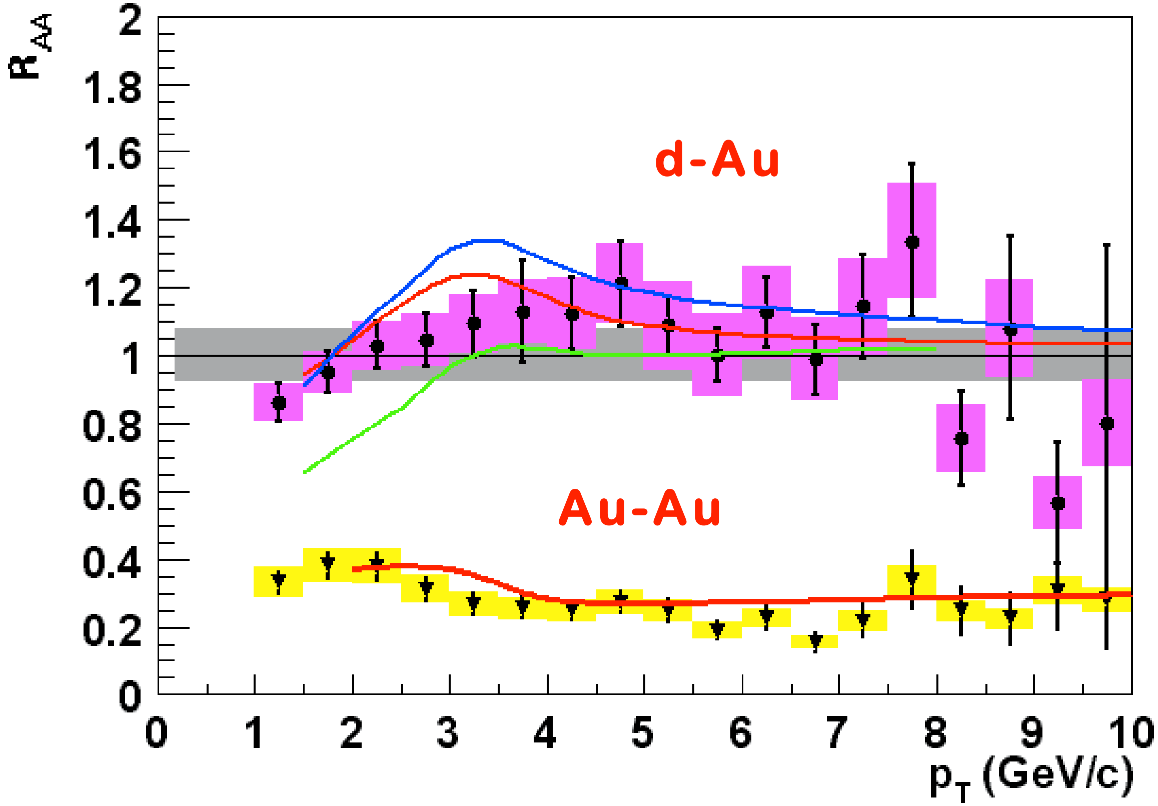
- ✓ Au-Au suppression **(I. Vitev and M. Gyulassy, hep-ph/0208108)**
- ✓ d-Au enhancement **(I. Vitev, nucl-th/0302002)**

See nucl-th/0302077 for a review.

$$\frac{dN_g}{dy} \sim 1100$$

ε=15 GeV/fm^3

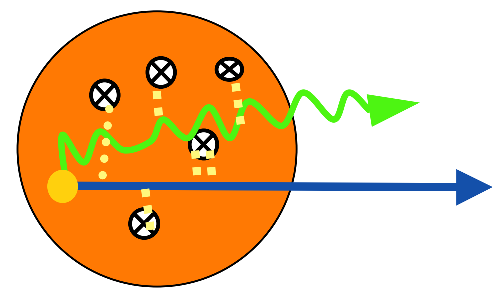
for Au+Au central



Suppression is Final State Medium-Effect

- **Energy loss of partons in dense matter--A medium effect predicted in QCD---Energy loss by colored parton in medium composed of unscreened color charges by gluon bremsstrahlung--LPM radiation**
  - ✓ Gyulassy, Levai, Vitev, Wang, Baier, Wiedemann…

  See nucl-th/0302077 for a review.
  - ✓ Baier, Dokshitzer, Mueller, Peigne, Shiff, NPB483, 291(1997), PLB345, 277(1995), Baier hep-ph/0209038, $\Delta E \approx L^2$

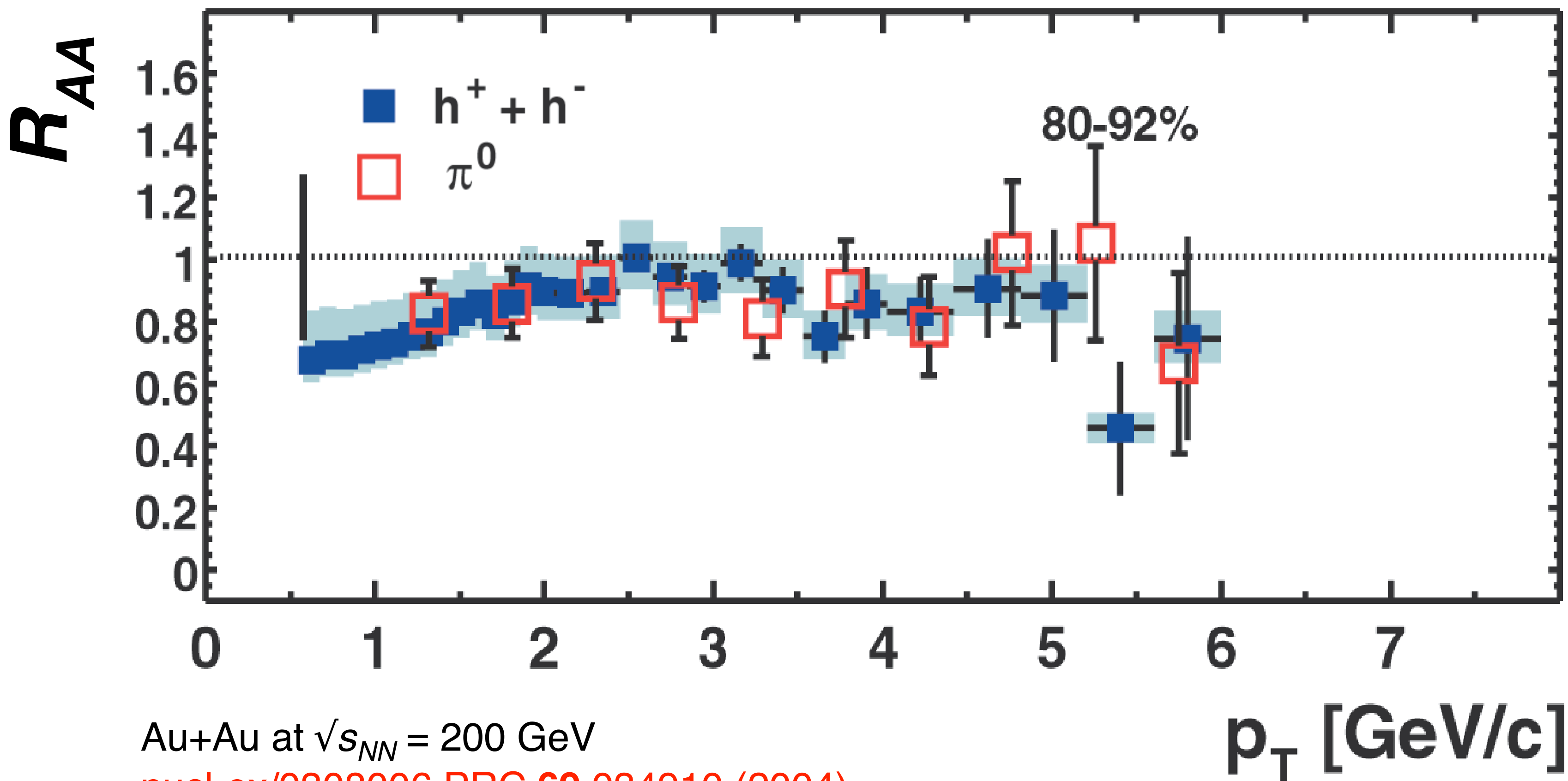


- From Vitev nucl-th/0404052:

$$\frac{\langle \Delta E \rangle}{E} \approx \frac{9 C_R \pi \alpha_s^3}{4} \frac{1}{A_\perp} \frac{dN^g}{dy} L \frac{1}{E} \ln \frac{2E}{\mu^2 L} + \cdots$$

- Can we measure these relationships ?

$R_{AA}(p_T)$ is constant for $p_T > 4.5$ GeV/c for both π^0 and $h^+ + h^-$



Au+Au at $\sqrt{s_{NN}}$ = 200 GeV

nucl-ex/0308006 PRC **69** 034910 (2004)

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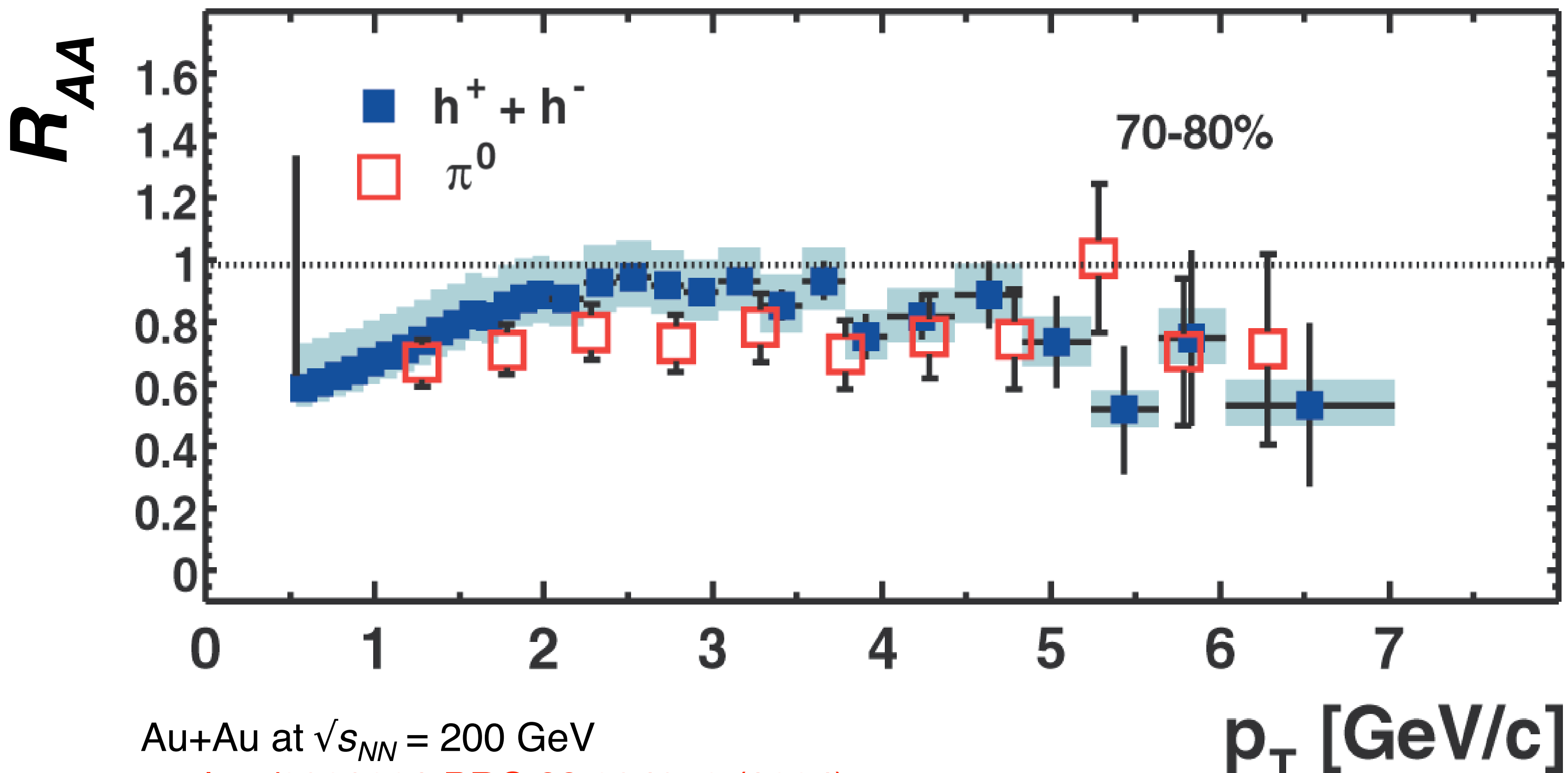

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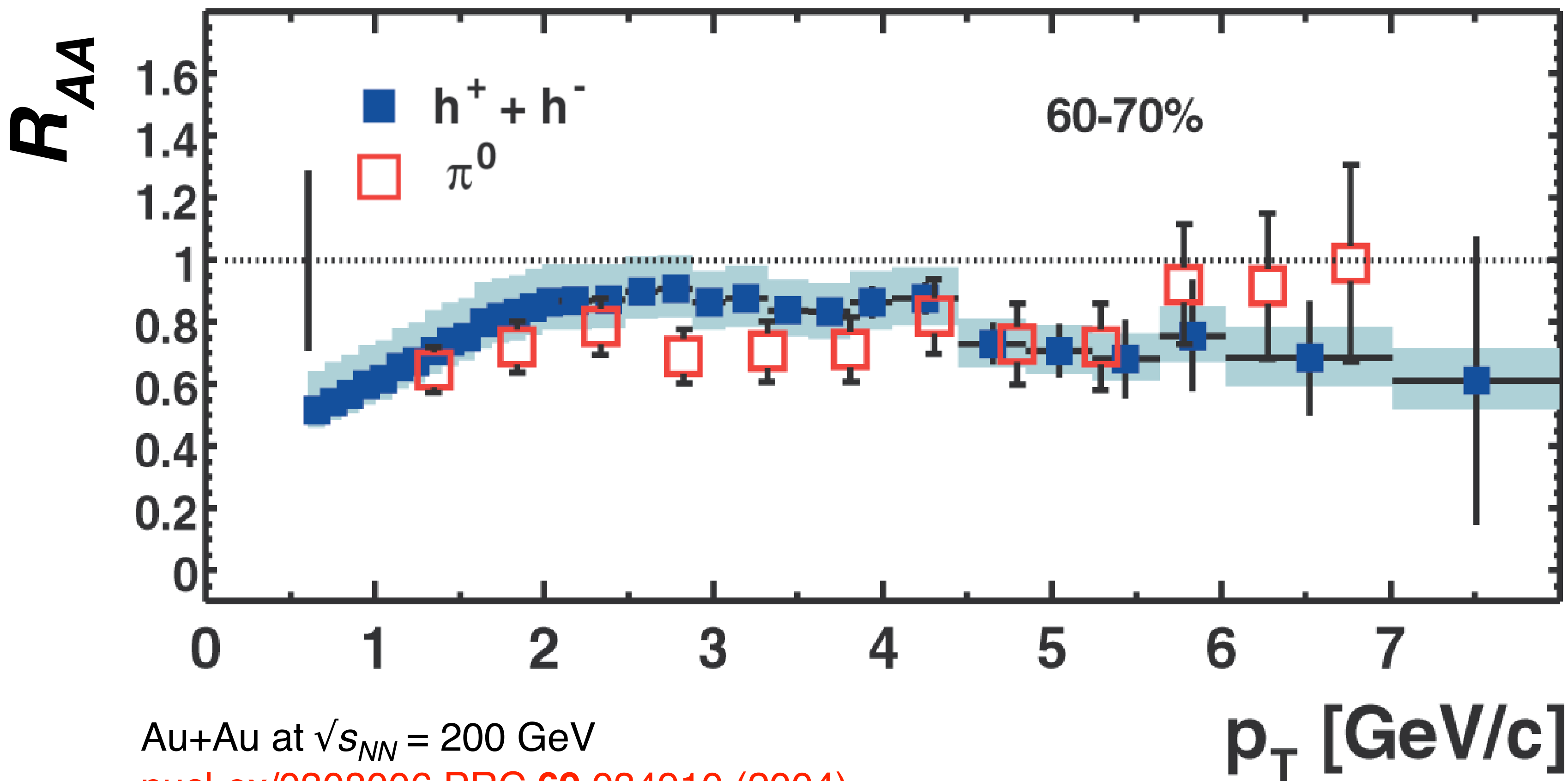

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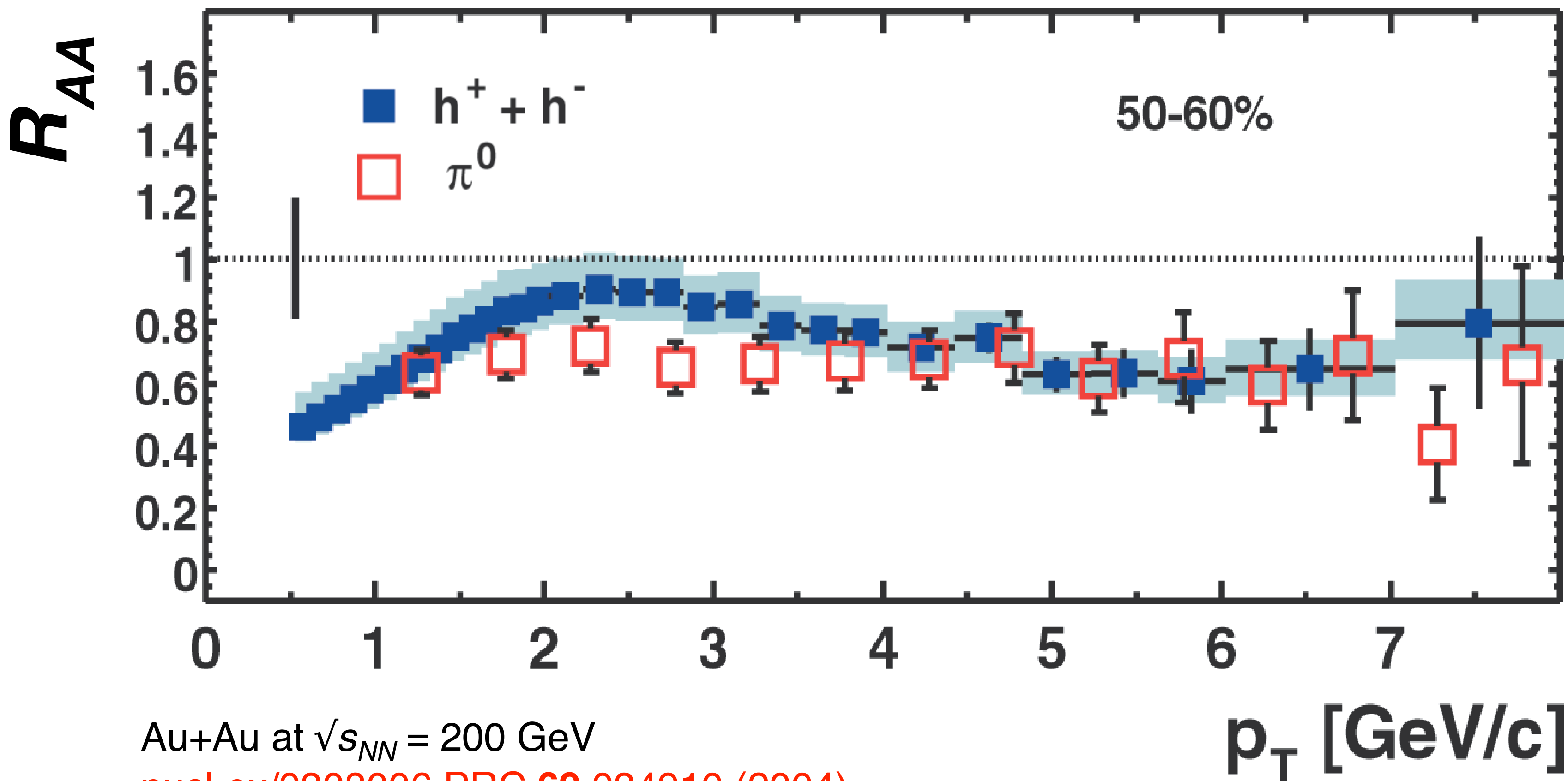

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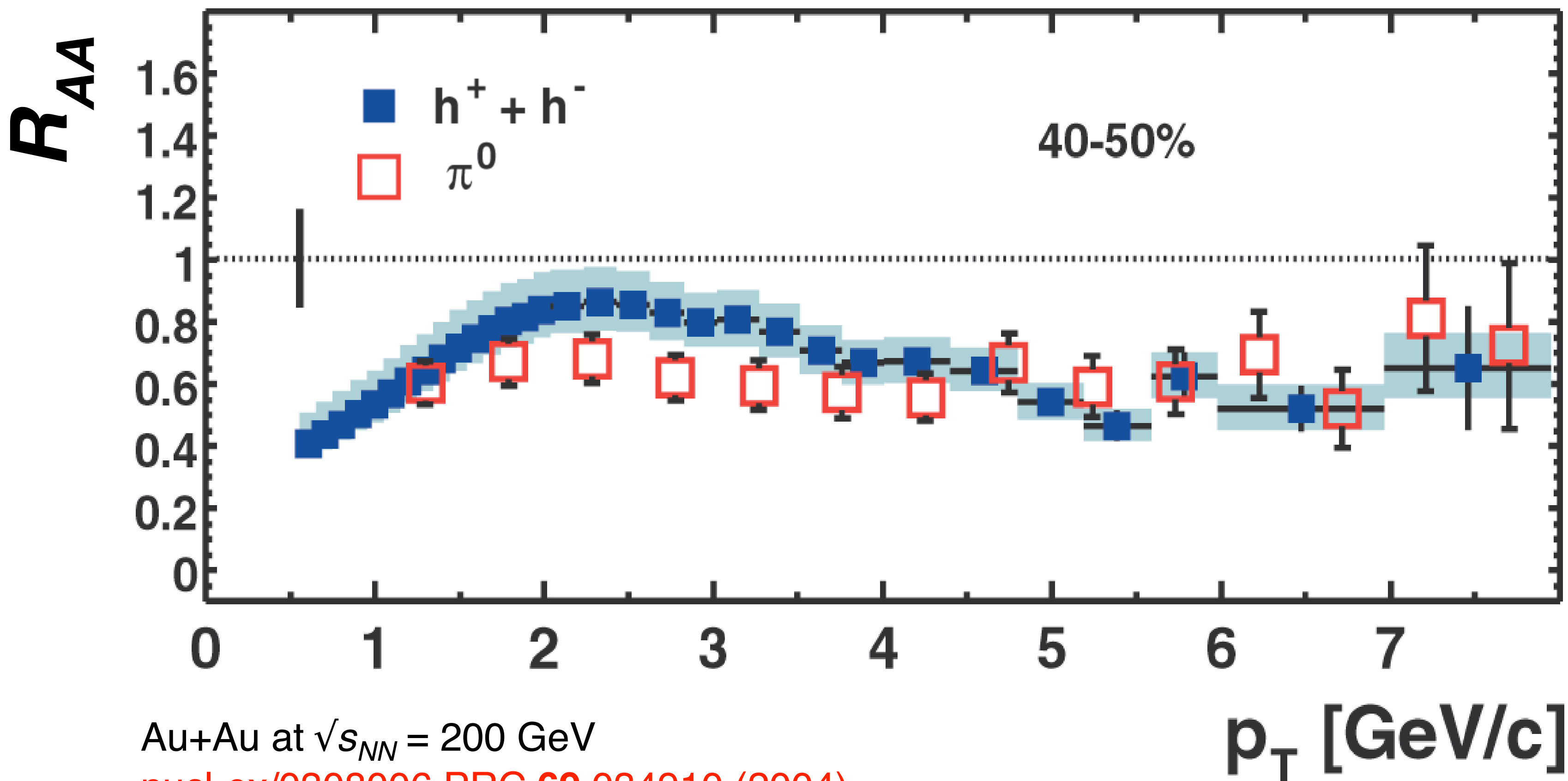

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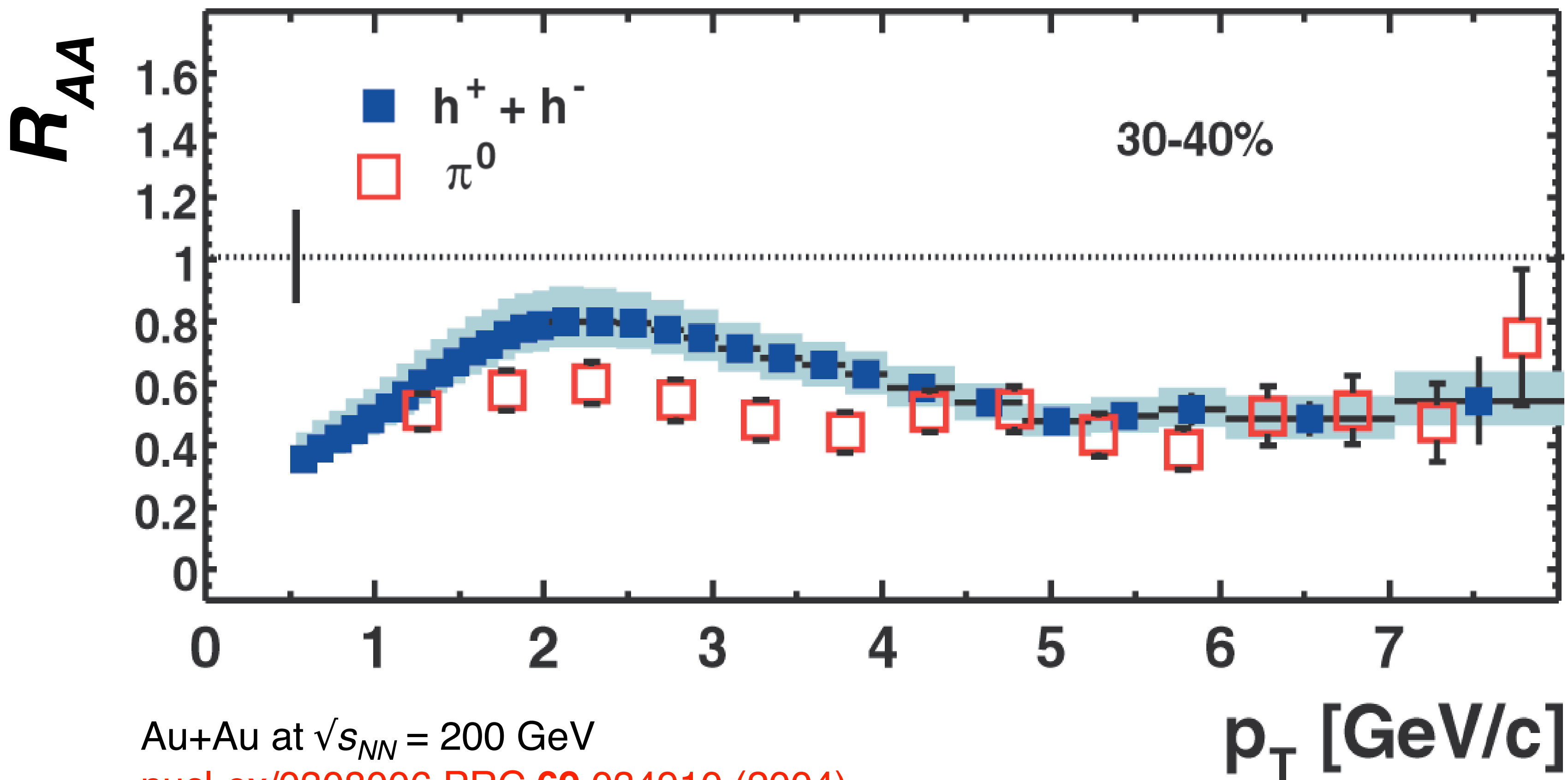

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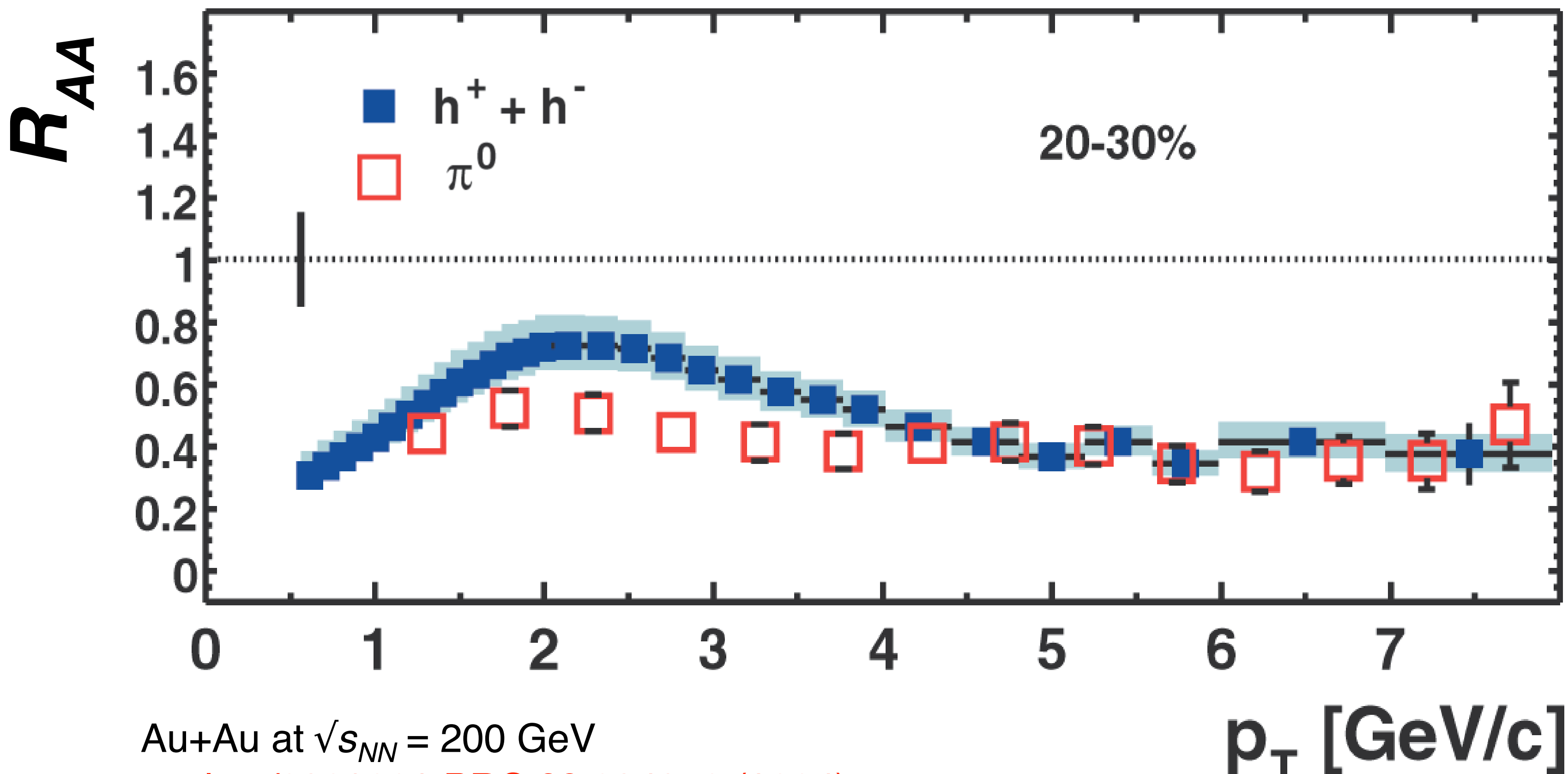

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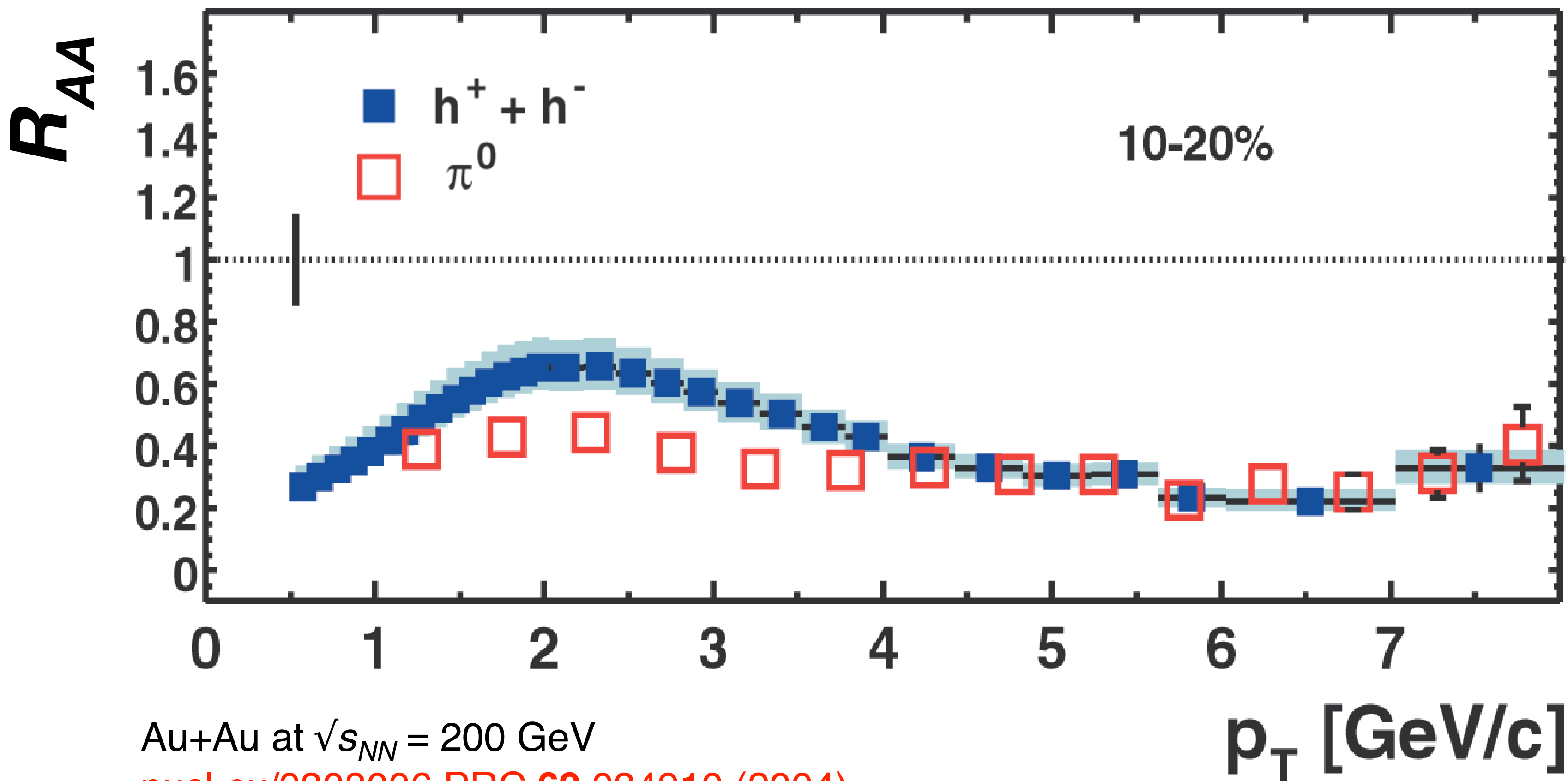

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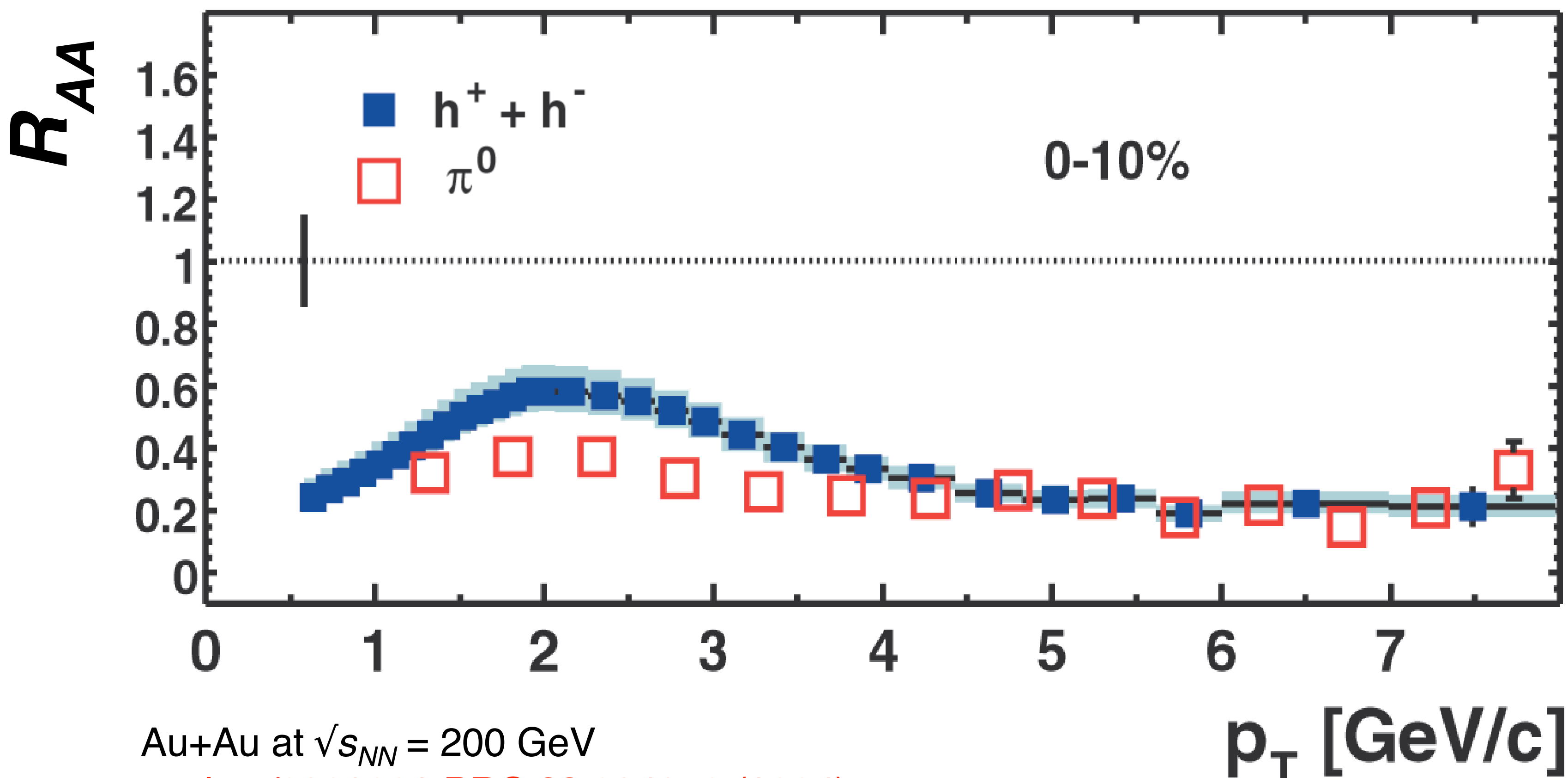

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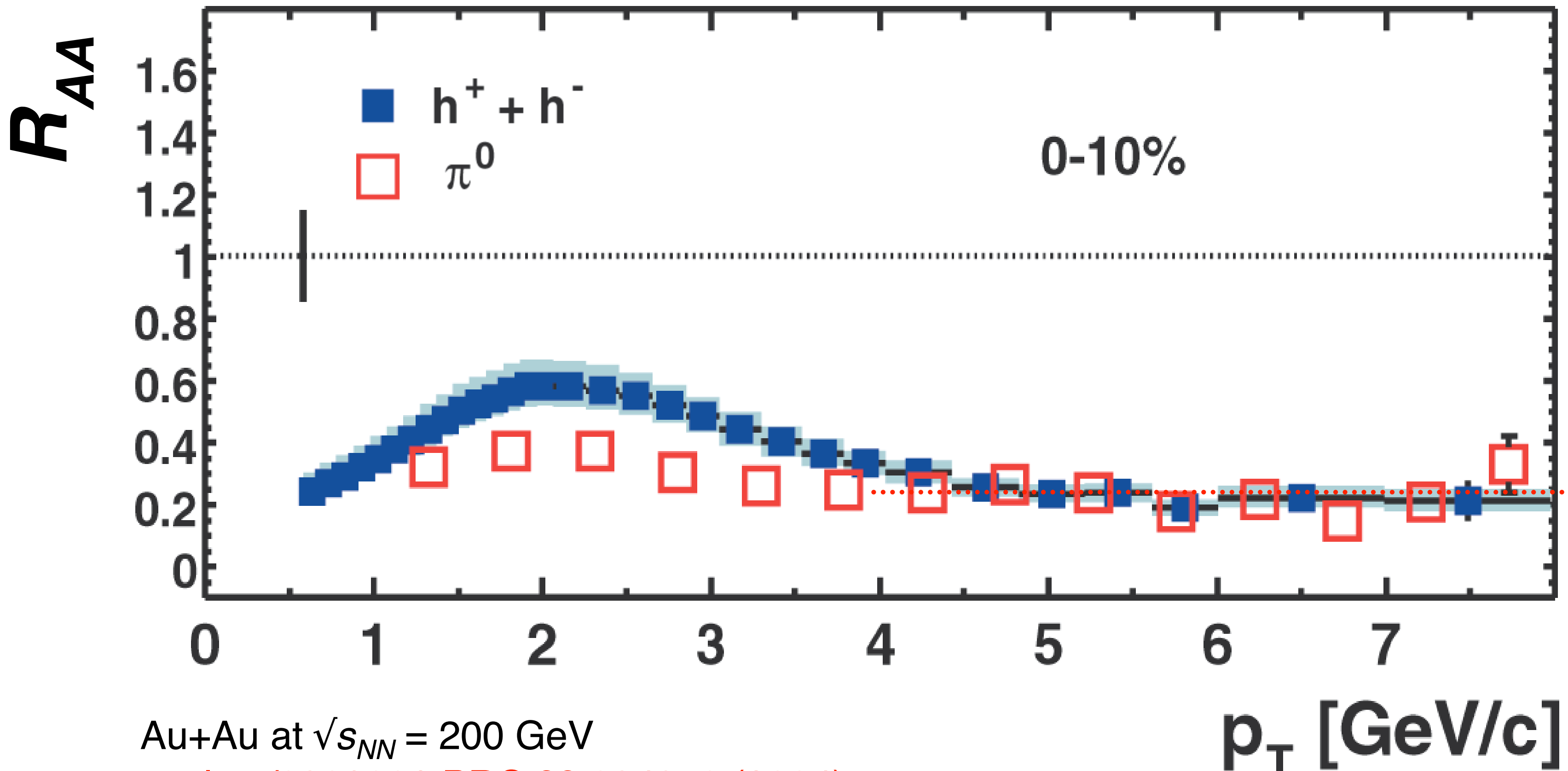

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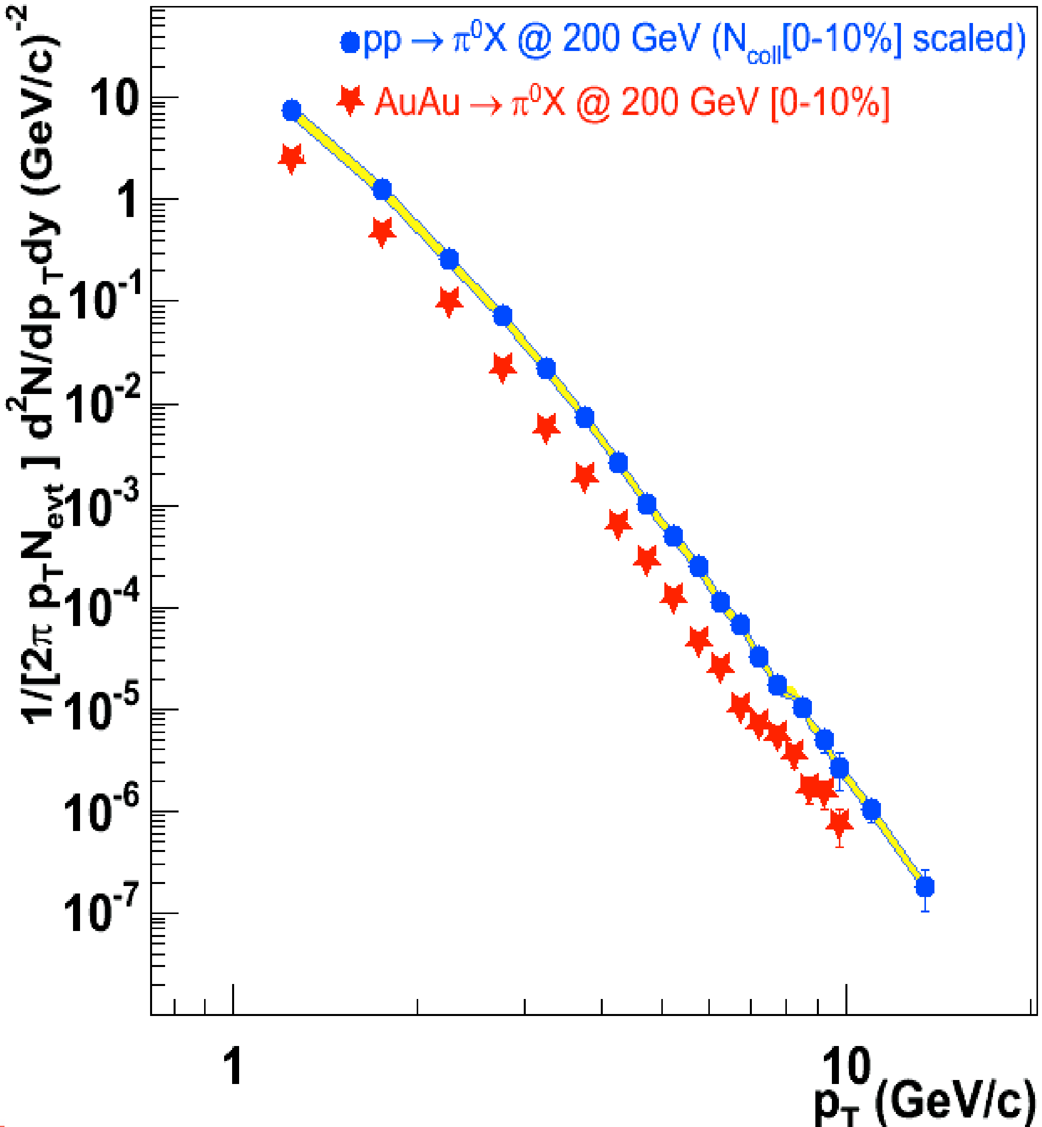
$R_{AA}(p_T)$=constant for p_T> 4.5 GeV/c, for both π^0 and $h^+ + h^-$

Mathematically the suppression is equivalent to a shift in the spectrum due to energy loss.



- $R_{AA}(p_T)$=constant for p_T> 4
- $d\sigma/p_Tdp_T$ is $p_T^{-8.1}$

$$R_{AA}(p_T) = \frac{M(p_T)}{R(p_T)}$$

$$M(p_T) = R(p'_T) \times \frac{dp'_T}{dp_T}$$

$$p'_T = p_T + S(p_T)$$

$$R_{AA}(p_T) = \left(1 - \frac{\Delta E(p_T)}{p_T}\right)^{8.1-2}$$

$$1 - R_{AA}(p_T)^{\frac{1}{8.1-2}} = \frac{\Delta E(p_T)}{p_T} = const$$

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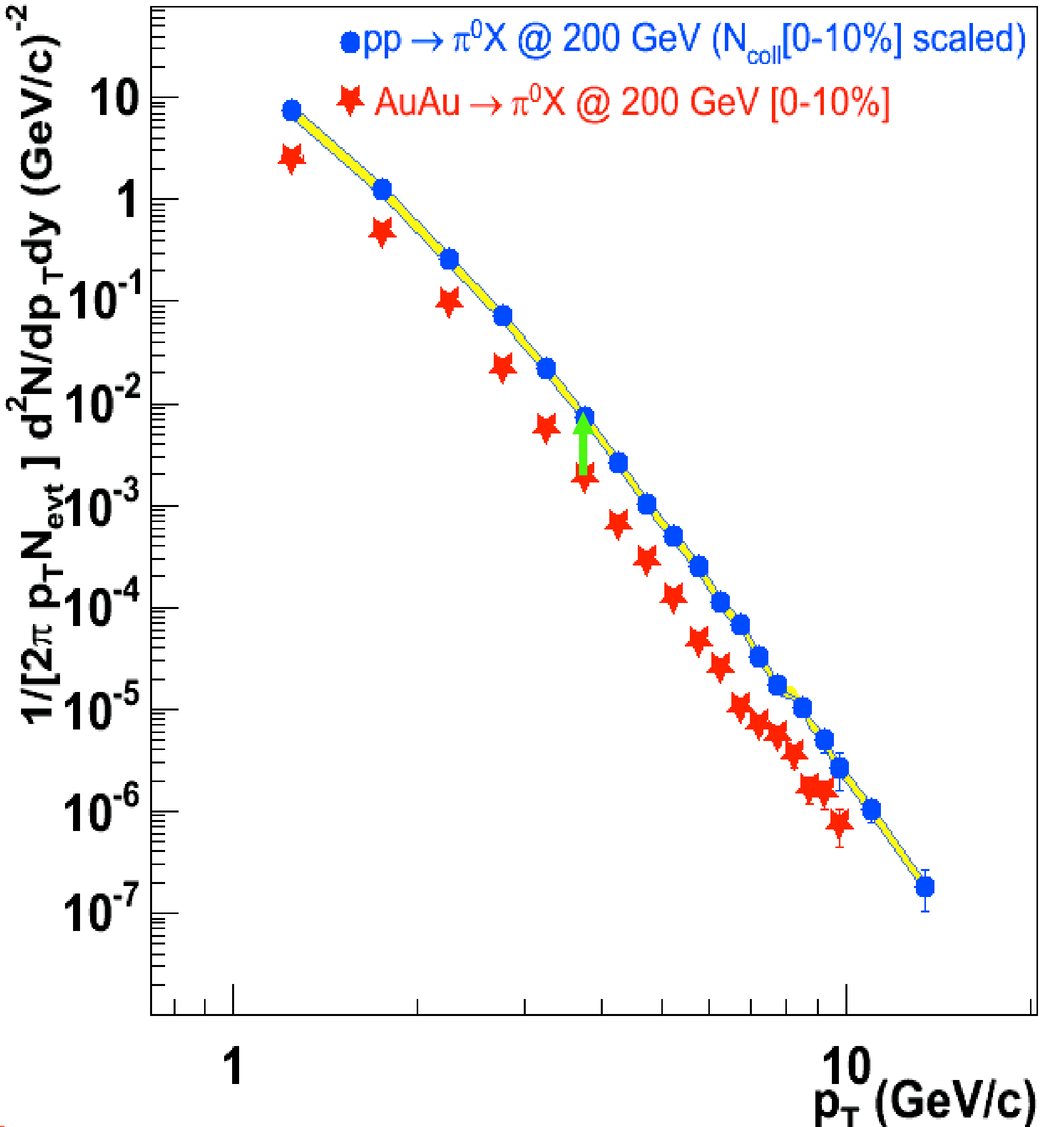

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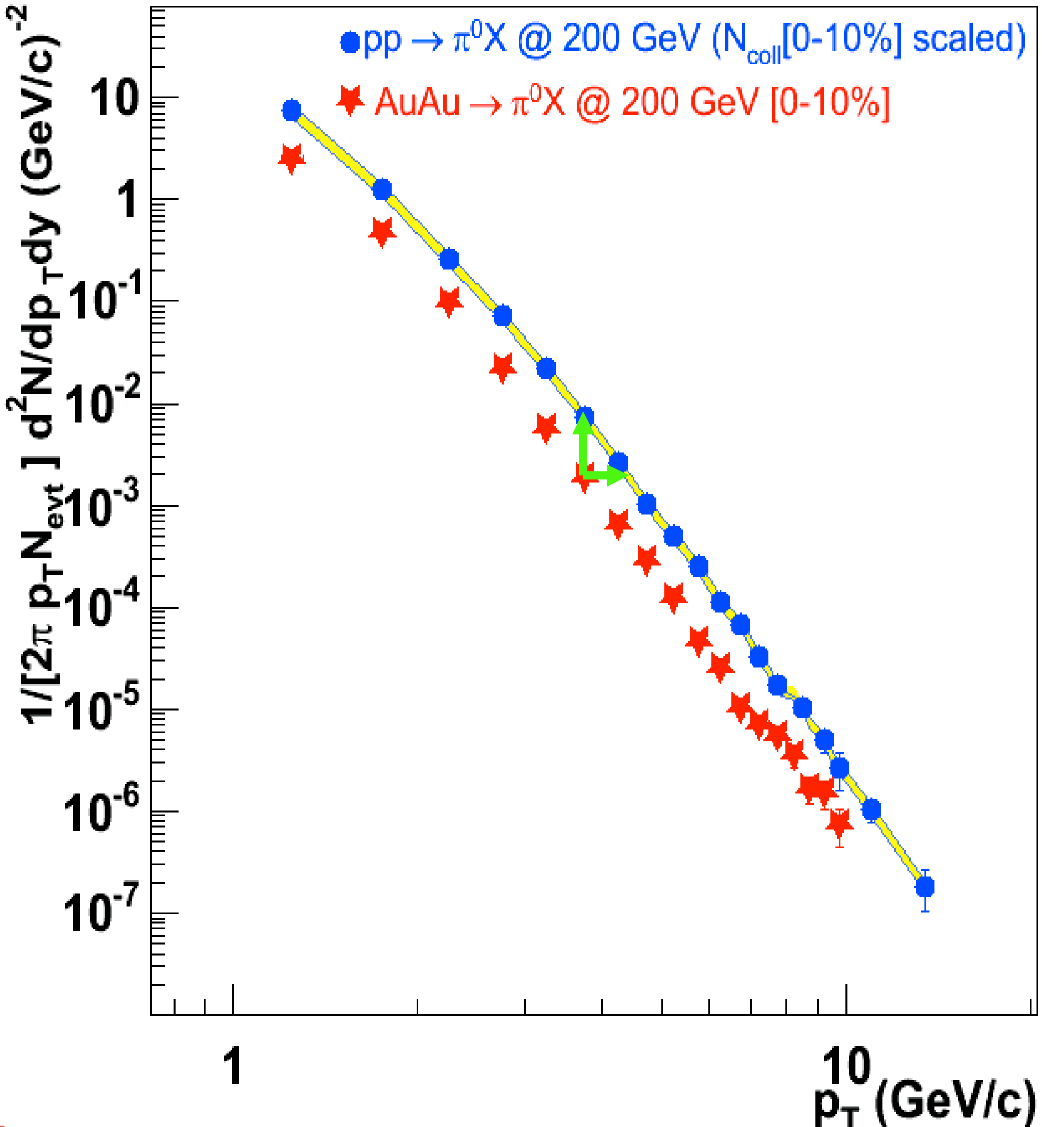

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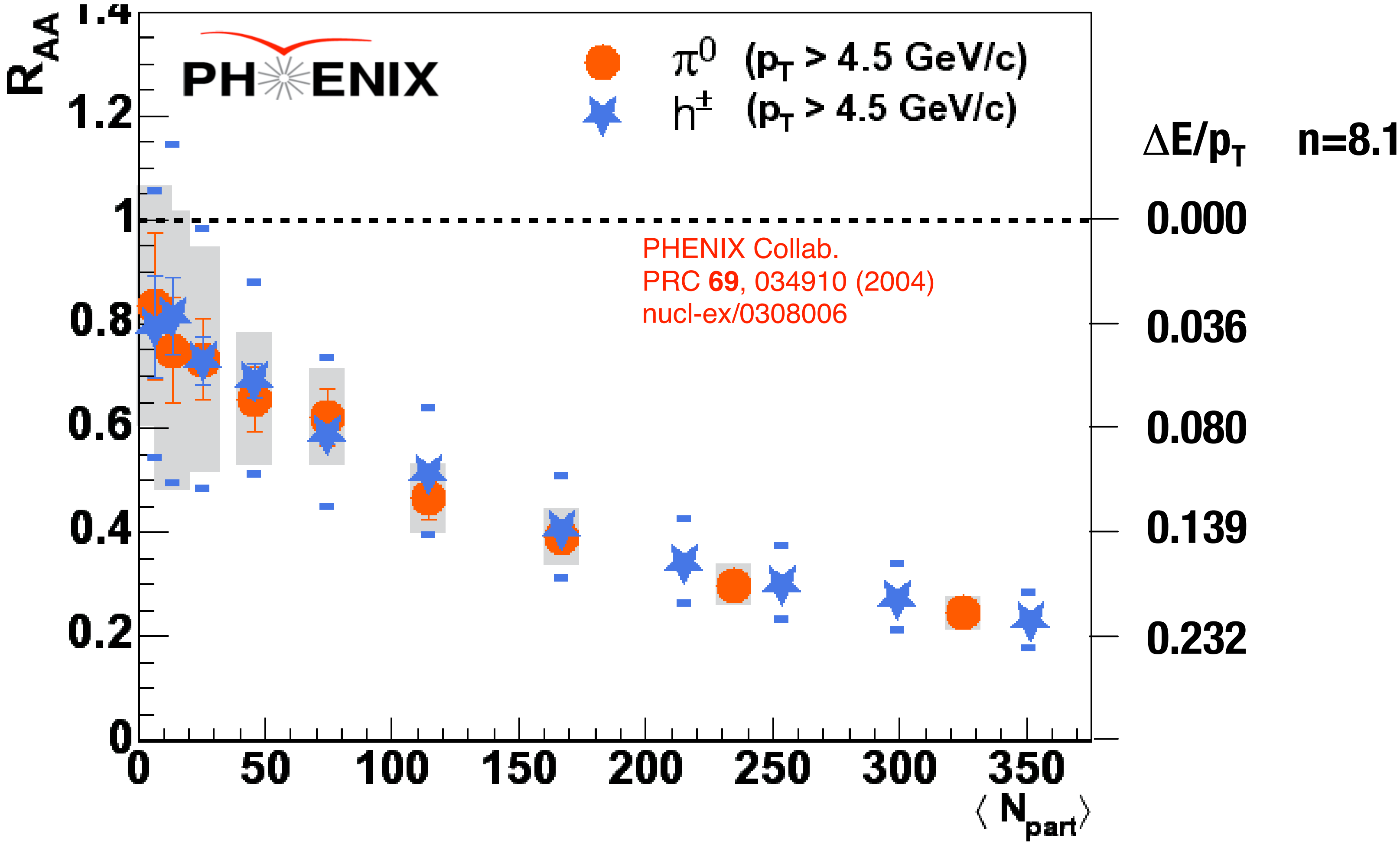
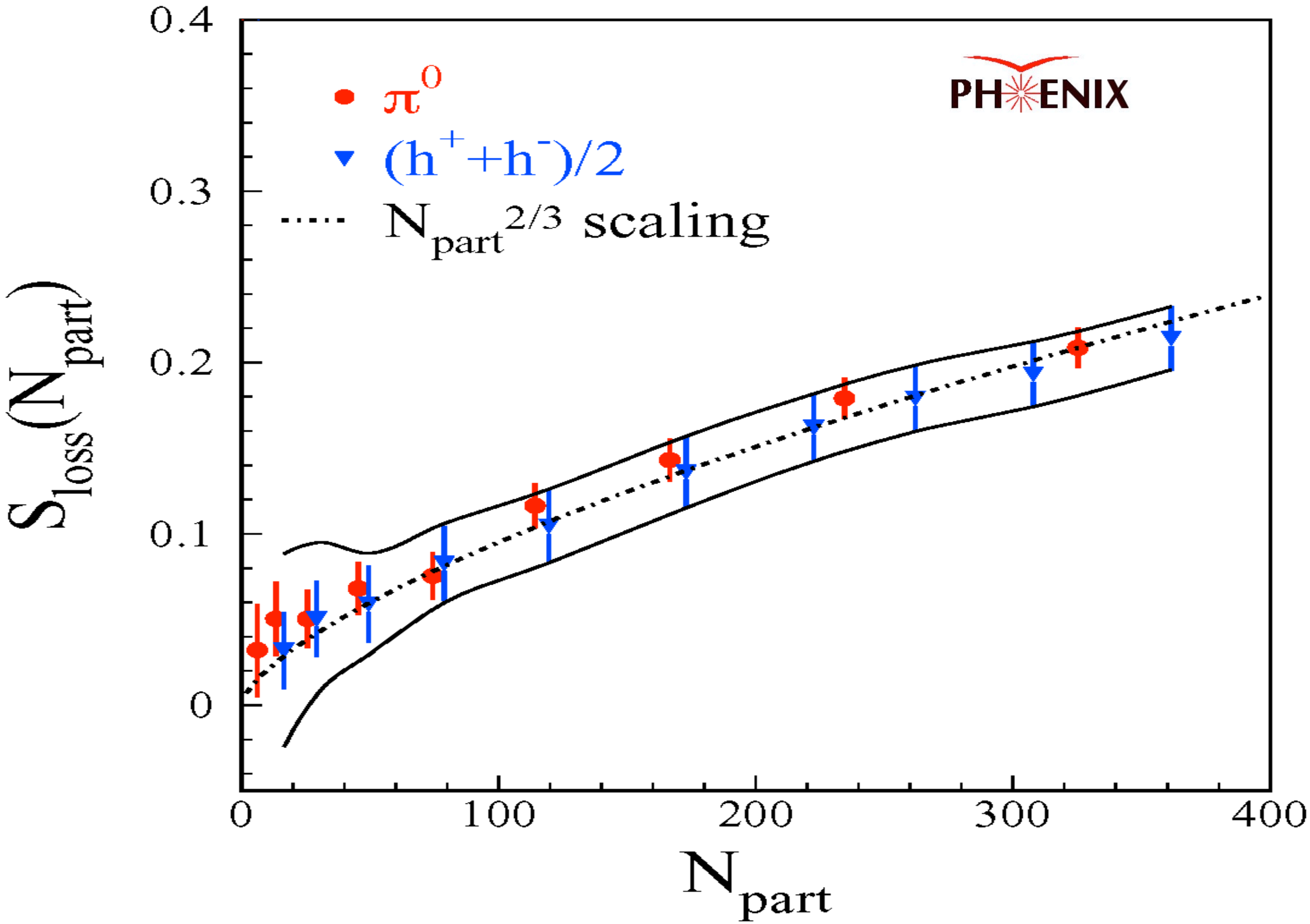
Estimate of $\Delta E/p_T$ from R_{AA} vs centrality

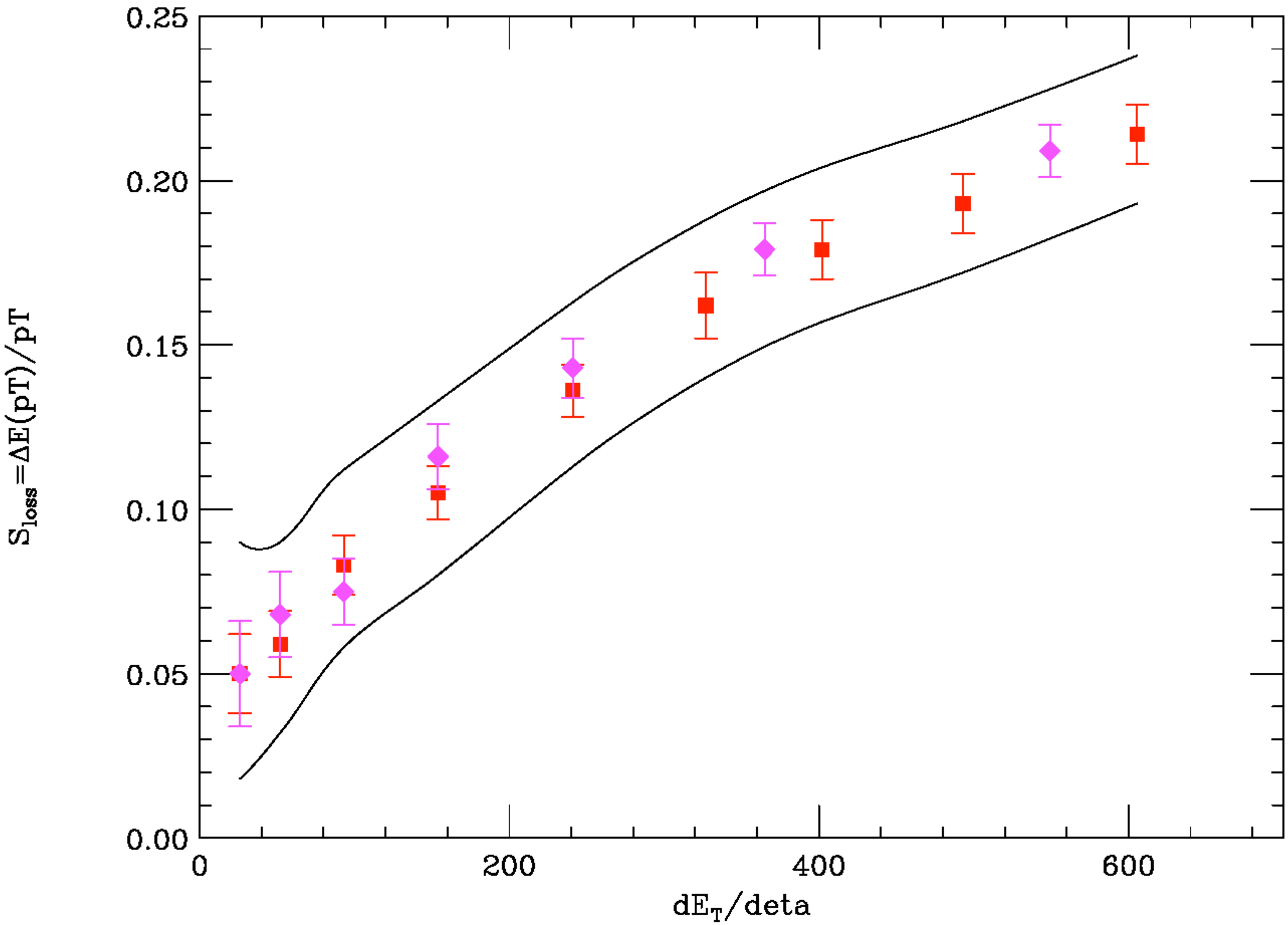


Nice---but nothing quantitative jumps out at me. Try other plots.

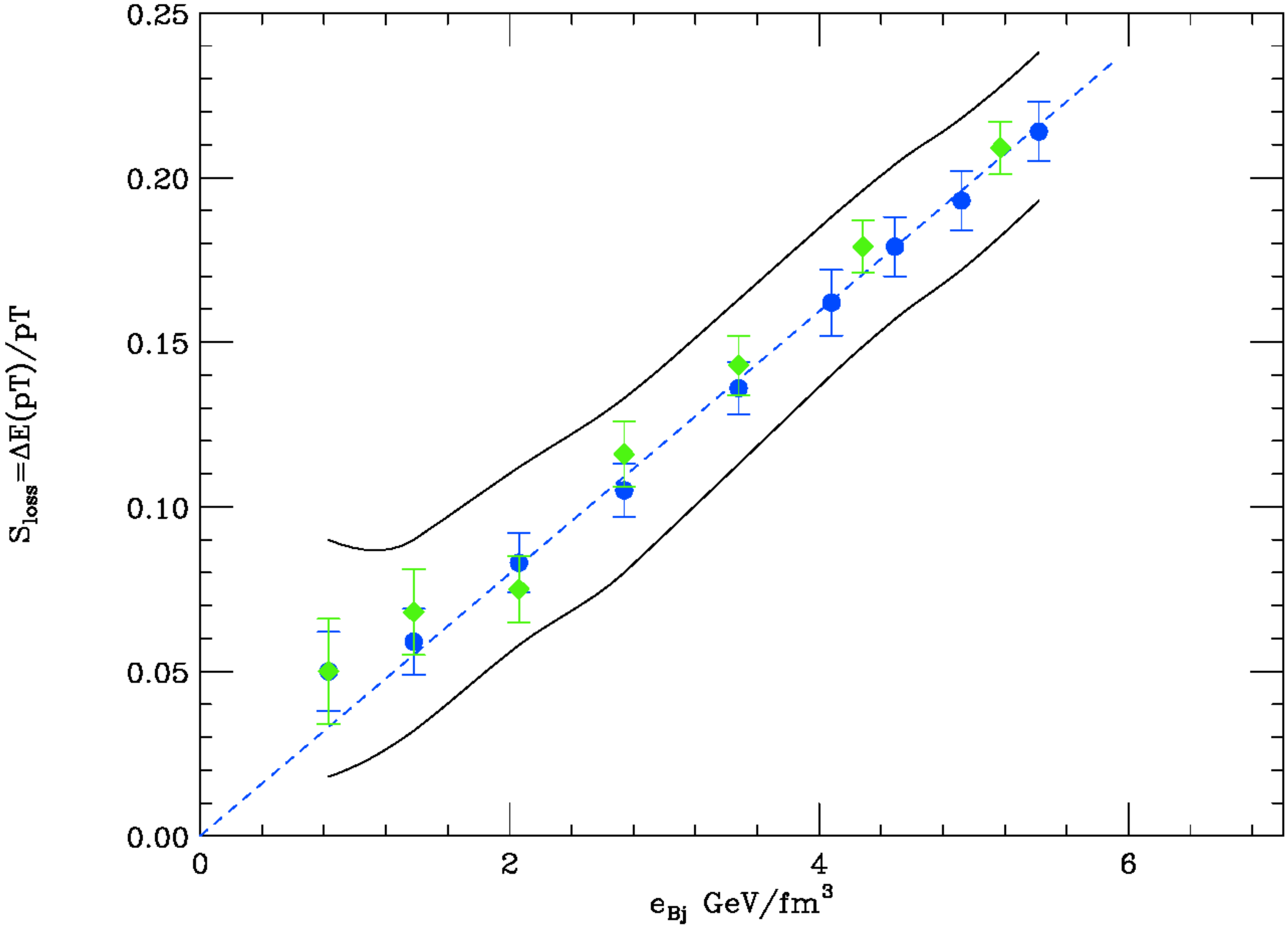
Plot $\Delta E(p_T)/p_T = S_{loss}$ vs centrality (Npart)



Plot $\Delta E(p_T)/p_T$ vs centrality $dE_T/d\eta$(Npart)



Plot $\Delta E(p_T)/p_T$ vs centrality $\varepsilon_{Bj}(Npart)$



!

Conclusions

- A crucial issue is whether RAA=1 means zero suppression, or do we have to account for the Cronin effect---Affects shape of $\Delta E(p_T)/p_T$ curve.

- Relationships are suggestive, but L dependence is obscure.

- Should do same analysis as a function of event plane since almond shape means L is different in-plane and normal to plane (Next Talk).

- Note that I use shift in spectrum, $S(p_T)$, and $\Delta E(p_T)$ interchangeably, but $S(p_T)$ is biased to lower energy losses since events with larger energy loss are buried under events at lower p_T with smaller energy loss. According to GLV true $\Delta E(p_T)$ is larger by a factor ~1.5-2.